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The Impact of Cybernetics on Arts in the 1960s

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2018-2019

Acknowledgments

I would like to express my deep gratitude to Dr. Elsa Ghossoub and Dr. Ralf el Hage, my research supervisors, for their patient guidance, enthusiastic encouragement and useful critiques of this research work. I would also like to thank Dr. Samar el-Hakim, for her advice and assistance throughout the years.

I would also like to extend my thanks to Dr. Elie Abou Rjeily for his support and I would thank Dr. Recardo Mbarkho, for his help in offering me the resources that I needed and directing me on the right path.

Finally, I wish to thank my mom and Dr. Dima Dabbous for their support and encouragement throughout my study.

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Introduction

In 1948, the American mathematician Norbert Wiener introduced a new field to the world of science called “cybernetics”. “ Norbert Wiener was the central figure responsible for the transformation of negative feedback from a technique used to control mechanical devices into a powerful conceptual tool, of general application, having to do with the organization of behavior”.(Hellman (1982), p.11) Feedback is one of the main theories that caused this shift in cybernetic art. This interdisciplinary field involved digital computing, information theory, and feedback control. Unlike traditional sciences that focus on material substances, cybernetics is concerned with immaterial elements such as ‘bits’ of information and focuses on the notion of control. In 1948 Weiner published ‘Cybernetics: Or Control and Communication in the Animal and the Machine’, marking the first public use of the word. In 1950 Weiner published ‘The Human Use of Human Beings’. His works discuss developments in science and technology relating to information and communication theory. His discoveries led to a theoretical shift that affected the sciences and humanities alike. This involved an epistemological evolution in several fields of knowledge merging and developing a systemic relationship between information and communication. With the emergence of new scientific knowledge, nature and society came to be understood as interrelated.

Wiener had been an active participant in pre-war interdisciplinary seminars. After World War II, he regularly took part in a series of small conferences of mathematicians, engineers, and specialists from other disciplines. The cybernetic theory became more commonly known during the mid-1950s. The concepts of information, communication, and systems had spread across social and aesthetic practices and discourses and became dominant in the US and in Europe by the late 1970s.“The needs and the complexity of modern life make greater demands on this process of information than ever before, and our museums, our scientific laboratories, our universities, are obliged to meet the needs of this process or fail in their purpose”. (Wiener (1961), p.18) To live a productive life is to have sufficient information. So, understanding communication and control became essential to understanding humanity in the modern age and the way we interact with society.

This thesis argues about the influence of cybernetics theories on art, particularly in relation to feedback and its emphasis on interactivity, and the behavior of the audience towards the artwork. To demonstrate it, this thesis will explore the relationship between cybernetic theories and art, as system art and sculptures. The first chapter discusses the transformation of the notion of ‘Information’ during the 1960s in the

field of aesthetics, particularly in relation to cybernetic art. This will be shown through the conceptual shift in understandings of art and artwork from object to process, from static to interactive, and from closed to open systems. A fundamental theory of cybernetics is based on the feedback looping process. This theory led to developments in art and sculpture as progress in cybernetics was reflected in the creation of a new form of art. Through analysis of works of art influenced by cybernetics, discussions will concern experimental developments in aesthetics that occurred in parallel with the development of information theory through cybernetics.

In the second chapter, the thesis discusses the transformation of art into a notion of Information which is explored through analysis of cybernetic sculptures, through discussion of the artwork’s process of Nicolas Schoffer, and the interaction between the observer and the artworks understood from a cybernetic point of view. This involves explaining the process of how the viewer discretely receives information through the senses, questioning the new formula of aesthetic conception developed through cybernetics theory. Measuring how information in an artwork is transmitted and is inherently a complex notion because it is related to the individual’s subjective ability to receive it. I chose Nicolas Schoffer’s artworks in particular for the analysis, because they represent most of the cybernetic ideas. Nicolas Schoffer's first kinetic art devices, Lumino, are considered important and innovative

and used for domestic daily life uses. These initial kinetic artworks would later develop and transfer from aesthetic design art to dynamic system art. Through this chapter, discusses also concern the metaphorical potential of this paradigm shift that was explored through sculptures, such as kinetic art and robotic sculptures. The influence of cybernetic theories is evident in the artists' artworks: it was adopted for exploring and experimenting within a new era of information that could be aesthetically perceived. Considering the impact of cybernetics on art theory and praxis, the ideas of Norbert Weiner were adopted by the artist Nicolas Schoffer, who investigated these theories for aesthetic purposes initially into discovering interactive kinetic art. A change in sculpture and automata can be noted during the 1950-1970s, whereby Western artists went beyond the traditions of the previously conceived mental and physical barriers between art and lived reality. Artists developed works "that entailed a form of intelligence related to the ability to communicate and interact with humans". (Jack (1975), p.343) These concepts and theories heavily impacted studies of Information within the arts and academia in the 20th century. To demonstrate this dynamic, by comparing and analyzing the works of both pioneer artists Nicolas Schoffer and Edward Ihnatowicz.

Chapter1

I. The Structure of Cybernetics

The term ‘cybernetics’ refers to a number of related developments in science and mathematics, involving a range of fields and techniques which overlap each other in different ways. These overlapping areas consist of automata theory, computer science, artificial intelligence, bionics, automation, and cybernation. The development of cybernetics began with the processing of information being reduced to a mathematical form in order to solve problems. It was then used to control mechanisms, machines capable of self-adaptation. Cybernetics is an interdisciplinary field was in part concerned with controlling the transmission of information, which developed during the 1950s and 60s. It reflects the scientific developments of this phase of time, that will be discussed throughout this chapter. Firstly, discussions will introduce the key concepts of cybernetics as a science and its development, secondly, discussing the studies and concepts in the field and explaining how the fundamental theories of cybernetics can help to define the relationship between cybernetics and art.

This section will discuss the origins of cybernetics and its purpose. Cybernetics was developed in sharp contrast to traditional cause and effect science and became a new scientific paradigm, where the observer decides “the system” he is exploring. Cybernetics began its ascendance during the 1950s through the ideas of American mathematician Norbert Wiener, who defined cybernetics as a “scientific

method based on different theories". (Hellman (1982), p.274) These include information theory, control theory, and automata theory. Moreover, it aimed at controlling and automating the behavior of mechanical and biological systems.

1.1 The Brief History of Cybernetics

Centuries earlier, Blaise Pascale (1623-1720), a mathematician and physician, said that "knowledge is like a sphere, the more the sphere of knowledge grows the bigger its contact with the unknown". (Cantu (2011), UNIVERSO KUBERNETES 1) Anything that could not be directly explained was attributed to the unknown world we call it this large sphere of the gray part, unlike the orange sphere that resembles the sphere of knowledge. (Fig.1)

Fig. 1: The Sphere of Knowledge, the inner sphere of knowledge expands bigger through discoveries of cybernetics,
(Cantu (2011), UNIVERSO KUBERNETES 1)

The sphere of knowledge (classical science) grew and expanded throughout history, and went into several developments. Traditionally, the “laws of physics were attributed to God. This God was the great designer, assumed to be the initial creator of everything in existence”. (Cantu (2011), UNIVERSO KUBERNETES 1) Over the last 100 years, with discoveries in Quantum physics, and later cybernetics theories, the sphere of knowledge increased again. Progress in these fields has unraveled some of the mysteries that eluded classical science. Cybernetics has given a man a new awareness of his natural gifts and capabilities and it also helped in developing the idea of Information. Today’s world is complex, dynamic, and systemic. How is it that religions and government institutions still attempt to explain and control the world using cause and effect methods? Maintaining a reductionist perspective of the economy, the laws of finance, and a mechanical vision of the universe, has serious limitations when it comes to explaining the complexities that are

everywhere. The new vision propounded by Norbert Weiner, especially regarding his theories on control and communication, has led to a new language that specializes in understanding complex systems. It is truly a different way of approaching science and it provides many answers to difficult questions that classical science was unable to provide. This new scientific paradigm has generated technology that has allowed for the discovery of a universe that is not static, but rather is expanding and had a beginning.

Cybernetics was developed after World War II, through Norbert Wiener's seminars and his colleagues' work, which transformed the realm of science and brought about a new paradigm and lasted for another forty decades after his death on March 18, 1964. The concepts that form the basis of cybernetics were known before Wiener coined the term. Through his research, he discovered that the idea originated in Greek philosophy, known as 'Kubernetes', which refers to the art of piloting a ship. The word Kubernetes represents the steering of a government. Religion, science, and government are systems. Each one acquires and shares knowledge, and each one resembles a different version of a system according to Plato: "each system imposes its own role, questioning reality and generating conflict as to whether each system has the possibility of meeting each other". (Cantu (2011), UNIVERSO KUBERNETES 1) The theory disappeared and was reinvigorated by the French philosopher Andre

Ampere in the 19th century. Ampere adopted the word ‘Kubernetes’ and transformed it into “Cybernetics” related to the science of governing a state or a country.

1.1.1 Birth of a Scientific Paradigm

After World War II, a group of 21 leading scientists gathered to discuss systems having a purpose and the underlying concepts, having the huge scientific potential for information feedback. The conferences where these scientists gathered are called the big bank in the ‘*information age*.’ The main characters that formed this meeting group for discussing new scientific ideas were Dr. Arturo Rosenblueth, a Mexican researcher, physician, and physiologist, who is known as one of the pioneers of cybernetics, Dr._Norbert Wiener, and Warren McCullock, an American neurophysiologist and cybernetician, known for his work on neurology theories and his contribution to the cybernetics movement. These professors were the founders of the cybernetic movement, each one of them contributed knowledge and ideas from their scientific expertise that created the path for others to further develop after them. The conferences were started by Dr. Rosenblueth, who organized monthly meetings during his stay at Harvard University in the early 1940s. It was during one of these events that he met Norbert Wiener. Later on, both of them got together with Julian Bigelow, an American pioneer in computer engineering, and produced their joint paper on technological mechanisms:

machines that pressure an objective. Another scientist who joined them later was Warren McCulloch, who was studying logical circuits made up by neurons. He carried out his work with the help of a mathematical genius called Walter Pitts. This small group of scientists contacted an anthropologist called Margaret Mead and her husband Gregory Bateson. Dr. Frank Freemont-Smith, an American member of cybernetics society that was created later in the 1970s, also joined the group and coordinated the activities of the behalf of the Macy Foundation, “the sponsor of the meetings”. (Hellman (1982), p.250)

Another participant was John Von Neumann a genius mathematician born in Budapest, Hungary. He was the first to make an address at the first Macy conference, which was a set of meetings of scholars from various disciplines held in New York under the direction of Frank Fremont-Smith at the Josiah Macy, Jr. Foundation. The first meeting of the group involved discussing the subject of the design of the electronic computer and comparing it to the human brain. The meeting addressed the work of Alan Turing, a computer scientist, and mathematician who had invented the electronic computer with programmable memory. A year previously Turing had had a huge breakthrough with his invention of the concept of the universal machine, the first initial idea behind modern computing. Turing’s ideas of electronic computers were discussed at the conference. The ideas the group formulated are still in use today. William

Ross Ashby was an English psychiatrist and a pioneer in cybernetics, and Heinz Von Forester was an Australian American scientist. They both also made important contributions to the new vision of the universe that was presented at Macy conferences. C. West Churchman, Russell L. Ackoff, and Stafford Beer distinguished themselves in the early stages with research involving the application of mathematical methods in solving management problems. Churchman and Ackoff produced studies in philosophy which contributed many ideas to systematic thinking. Ross Ashby and Beer, in turn, applied control theory to biology and human organization, respectively. The next section will lay out the main theories that came out of the groundbreaking work of these scientists.

The Macy conferences between 1946 and 1953 resulted in the development of a new description of the modern electronic computer with programmable memory. John Von Neumann showed a diagram of its architecture for the very first time in the year 1945.

During the first meeting, Rosenbluth and Norbert Wiener had explained a new concept on feedback messages and information as part of a theory of communication. In the second meeting, which took place in September 1946, Wiener defined information as negative entropy. He used the exact same formula but with a negative sign, so that information is order and entropy is disorder. By using this formula, the amount of information in a message becomes a measurable quantity. Wiener and Gregory Bateson,

(an English anthropologist, social scientist, semiotician, and cyberneticist), named the bit as the binary digit, as the basic unit for information. We can, therefore, say that the information age was born at that very moment.

Bit = binary digit O, 1

1.1.2 Theories of Cybernetics

Throughout history, the knowledge of science has developed through the collaborations of various groups and institutions including scientists, mathematicians, and biologists, etc. After World War II, science became more interdisciplinary and a focus on communication and control developed. Then, Norbert Weiner's book, *Cybernetics, or Control and Communication in the Animal and the Machine,* was published. Cybernetics was defined as the "science of control and communication in the animal and the machine". The theories suggested a fundamental understanding of two important aspects of information and communication. The elements that connect information and communication are classified into three parts; "first, by highlighting the convergence of medium, information, and communication in the coding/decoding act functional to the transfer of informational content; second, by defining the message as a discrete or continuous sequence of measurable events distributed in time, and third, by considering the

organization of all the elements constitutive of such communicational circuit". (Iuli (2013), p.232) There are two main models of cybernetics, one is related to software, a collection of data, and the other to computer-programming which is the process of building computer programs. These two models, one that concerns computer software programs like computer digital art and drawing programs, and computer programming which is the language used to program computers, join the aspects of both the notion of a message and the quantitive content of the communication. This understanding was applied to physics, biology, and mathematics in the nineteenth century. However, after World War II, scientists were focused more on engineering and information sciences. The studies of Weiner's communication system resulted in discovering the "*feedback loop system*." Feedback loops are created when reactions affect themselves. The feedback loop plays a crucial role in the identification of dynamic systems where circular causality is key to its evolution. This process circuits of information can be positive or negative. This concept explains how control is achieved in automatic machinery, animals, and organization of all types: "In which information is fed into the system (as input), and system behavior (output) is functionally steered by built-in servomechanisms that re-inject information (as new input) back into the system (feedback)". (Iuli (2013), p.232)

Below is a diagram of a typical feedback loop system:

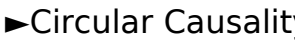

Fig. 2: Circular Causality

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Feedback Loop process of data resulting in the Output (goal), (Cantu (2011), UNIVERSO KUBERNETES 1)

Another way of describing a feedback loop is by starting with a black box that receives an input and generates an output, redirecting the

process into its final goal. (Fig.2) A comparator measures the output and compares it to the desired goal, and sends an arrow signal to the input. As this information arrives at the input, it generates the necessary response into the output to correct the signal. This is called a circular causality. “Positive feedback loops are useful for creating change but can lead to negative consequences if not moderated by negative feedback loops. Negative feedback loops are effective for resisting change”. (Beaubien (2019), The Great Mental Model). Stafford Beer’s Watt Governor is an example of a device that automatically controls the speed of an engine using a feedback system. The industrial revolution and the growth of cities, the expansion of scientific and technological knowledge in the 19th century were propelled by the Watt Governor, which is a “device, a classical example centrifugal governor, also known as the Watt or fly-ball governor on a reciprocating steam engine, which uses the effect of intertidal force on rotating weights driven by the machine output shaft to regulate its speed by altering the input flow of steam”. (Hills (1996), Power From the Wind)

The development of cybernetics in the realm of science led to artistic experimenting with the theories, as will be discussed in the second section of this thesis. Three major developments in cybernetics impacted the arts. These three basic concepts are based on information theory: the notion of a message and quantifiable amounts of information; on control

theory using the feedback loop, and on automata theory applied to Alan Turing’s machines and network. These theories will now be explained.

1.1.2.1 Information Theory

Information theory is characterized by dealing with a set of possibilities. What is important is the extent to which the system is the subject of determining and controlling factors. The energy necessary for the transformation is not important, but rather it is taken for granted. As a result, the flow of information and its process lead to the needed aim. The development of this understanding connected cybernetics to biology and then the soft sciences. So, cybernetics is defined as the study of systems. Information theory deals with the core of communication and can be in any form. Weaver, a specialist in the field of communication and engineering, said that “there is no specific one message or symbol used; it could be as a form of written letters or words, or musical notes, or spoken words, or symphonic music, or pictures”. (Apter (1969), p.258) The notion of a message is referred to as the effect of any sequence of measurable events distributed in time. These events can be the symbols of a communicative message and information. The average (rather than total) amount of information per symbol event in a message is known as its entropy. The theory can be applied to different formulations, such as in sequences of events in biological systems depending on the different information in its different stages and times of development. The theory

can also be applied to the arts. For example, the more a message is abundantly received, the more information it has and the longer the contemporary artist's obsession in the randomness may be seen as an attempt to increase the information he is conveying.

How can information be encoded and then decoded? The information that is used in the feedback concept is transmitted through communication engineering, such as telephone wires, radio, TV, etc. For example, when an error occurs in a musical symphony by an instrument is encoded on the radio for transformation, it is resurrected then transmitted, it may be interrupted by another intrusion of uncontrollable noise, then edited again and decoded, resulting in a better structure ready to be received. This process, a feedback loop, can be applied in different forms, including artistic communication and operators controlling complex pieces of equipment. A feedback loop is edited in case of an accidental error for the purpose of receiving the information in its best form for improving and reaching the goal.

1.1.2.2 Control Theory

Control theory concerns control messages that affect systems, which are controlled by themselves towards the intended goals. Information is used within a system and between a system and its environment for attaining the possible outcomes. Negative feedback is

fundamental for control theory; the process of an outcome is re-edited in a system that repeats in a negative direction in order to control it. (Fig. 2). For example, temperature control in the human body.

The process of a negative feedback loop is called a homeostatic system, which contains a limited certain outcome. Positive feedback can use negative feedback in order to increase its efficiency. For instance, “power brakes amplify pressure on a brake, braking being a form of negative feedback controlling the speed of the vehicle”. (Apter (1969) p.260) Theories have been developed concerning living organisms, like animals and humans, and non-living entities. The living organisms are able to solve or work out issues efficiently towards a desired future outcome, whereas the non-living ones are subject to the law of cause and effect. Therefore, they are driven by the past instead of the future goals. “Purposeful behavior by animal or machine can be explained in identical ‘cause and effect’ terms”.(Apter (1969) p.260)

1.1.2.3 Automata Theory

Automata theory is based on different kinds of systems that are related to different types of behaviors. Automata theory is indirectly connected to the development of cybernetics rather than as directly as theories of information and control. Automata theory is more concerned

with the logic of a system. The difference between information theory and automata theory is that information is essentially part of probability theory and is concerned with quantities. Automata theory, on the other hand, is related to proof. It could also be called ‘The logic of systems’. The term Automaton means “a system or machine which is deterministic and to which probability notions do not have to be applied”. (Apter (1969), p.260) Therefore, automata theory differs from the other theories in the sense that it is more concerned with what it can and cannot perform. “In automata, the automation is typical, sort of an image of a thickness of a line or diagram in Euclidean Geometry”. (Apter (1969), p.260) So automata are concerned about the data that is invisible contrary to the example of the thickness of the lines in Euclidean Geometry.

Automata theory is concerned with the question: is there any logical contradiction in the idea of a system being able to reproduce itself and if not, what are the requirements? This work is derived from the work of Von-Neumann, a Hungarian-American mathematician, physicist, computer scientist, and polymath, and is also known as the von Neumann model or Princeton architecture. He created a document about design architecture for an electronic digital computer.

Alan Turing, the English mathematician and computer scientist, was the first to discover the networking system of a machine in 1936. The

Turing machine can be thought of as a finite automaton or control unit equipped with infinite storage (memory). Turing played a crucial role in discovering the computing programming system that was adopted. What is the connection between cybernetics and Turing? “Probably that cybernetics is the biggest bite out of Knowledge that mankind has taken in the last 2000 years”. (Gregory Bateson). For years it has been rumored that Apple’s iconic logo, with a missing bite on one side, was inspired by the circumstances surrounding his death. He committed suicide by eating a cyanide apple in 1954. Another theoretical framework used in automata theory is the network. The network is constructed in an interconnected process, all the elements are connected together. This theory was first invented by McCulloch and Pitts. The network functions as a complete entity in order to transform information, whether this information is put into an input in different forms or temporal configurations and produces different outputs. “ The algorithm of a network is not represented by a program as it is with a Turing machine, but is implicit in its structure”. (Leonardo, p.257-265) A network is a process of sequence method for solving problems. It is usually used for calculation, data transformation, and other mathematical computations. The algorithm is also used to manipulate information in various ways, such as searching for new data or including new information. Cybernetics is more than one system of theories and contains many purposes that use precise conceptual techniques. After having defined history and the most essential theories of

cybernetics, this thesis will now explore how these theories are used in art.

1.2 The Relation between Cybernetics and Art

The theories of cybernetics influenced the realm of art from various aspects and the artists themselves, which attracted their attention to explore and experiment with new material. This includes art in its different fields such as musicians and poets and visual artists.

The most important aspect of the relationship between cybernetics and art is understanding the complex human behavior concerning cybernetics theories, in which a highly complex type of behavior called “artistic” is a type of behavior involving control and communication. The purpose of the “artistic behavior” is to stimulate the emotional and intellectual part of the human nervous system. This involves the artist’s behavior and fusion into his artwork through the process and the material being used. For example, the artist may get influenced by negative emotions, noisy channels, random disturbance, and dysfunctional devices or other materials. The artwork of the noisy channel is communicating directly with the audience through interrupting. Using the distraction as an element through a musical instrument or other. This result is observed in the emotional and intellectual interaction of the spectator's behavior. This entire sequence is related to the feedback loop

involving the interaction of the artwork with the artist and between the artwork and the audience and between the audience and the artist through criticism. So, cybernetics theories are more complex rather than simple. Through criticism, and understanding of the control and communication systems, the artist can benefit from improving his technique.

1.2.1 Convergences of Cybernetics and Art

The convergences between cybernetics and art can be understood in four steps. The first is concerned with interaction with viewers; the second involves putting visual forms into actual motion; the third relates to the concept of the feedback loop, and the fourth focuses on temporality (time).

1.2.1.1 Interaction with the Audience

Jack Burnham, an American writer, said that "The specific function of modern deductive art has been to show that art does not reside in material entities, but in relations between the audience, and the people between the components of their own environment." The term 'Interaction' is used to express the idea of multiple levels of interrelations. Interaction with the audience can be classified into three types: first, when the art is equivalent to interactive systems. Second, the material objects; that where the artwork reverses the material entities. Third, when the

artist plus his artwork plus the audience results in what is called an interactive cybernetics system.

Later on, Burnham defined art as a cybernetics system composed of a network of feedback loops. As mentioned previously, a feedback loop is a cycle of input- process- output, which requires the flow of information. The potential of the artwork is dependant on the interaction: the exchange of information between the artist, the observer, and the object as artwork and environment. So, cybernetics art is not just an interactive system, but also connected to the quantity of information perception and feedback circuit of information between the spectator and the artwork, which result is the cybernetics system. For example, Roy Ascott, a British artist created the artwork '*Change Paintings'* in 1960. The viewer altered the artwork by sliding the panels along a horizontal axis (process), to the composition of the interactive constructions, which changed over time acting as (output). Ascott stated that: "art was located in an interactive system, rather than residing in a material object." The appearance of the cybernetics theory encouraged the interaction and enlarged the potential of an artwork.

1.2.1.2 Dynamic System

Another type of relationship between cybernetics and art relates to putting a visual form into actual motion. Unlike Ascott, many twentieth-

century artists were not familiarized with the concepts of cybernetics, but still experimented with processes of kinetics, interactivity, and audience participation. They were relying primarily on the aesthetic features or perception of an artwork as a tool to create art to explain and exhibit their artworks. An example is “The Bicycle Wheel”, Duchamp’s artwork of 1913, which contains a bicycle fork with a front-wheel mounted upside-down on a wooden stool. It made motion an essential quality of the art object, which also alludes to the aspect of time. The outcome was not just aesthetic, but a shift from science to art.

In the process of experiments between art and technology, there were a certain number of ‘failed artworks’ as well. For instance, the ‘Cybernetic Serendipity’ by Jasia Reichardt was an exhibition of cybernetics art, included computer printouts of musical analysis, computer-designed choreography, and poems. Unfortunately, because of the limited budget and poor packing and handling when shipping, parts of the contents were destroyed. Jasia Reichardt herself disowned the work, and so it became a failed project. But, are these kinds of artworks really a “failure”? Jasia Reichardt says: “ In my point of view those are similar to experimental art”. That experiment with anything and everything, “With raw matter or time, relationships among people, things and tendencies.”

1.2.1.3 Concept of Feedback

This relationship involves the concept of feedback loops. Cybernetics theory encourages the aesthetic strategy of engaging the audience more directly in a work; the use of the feedback of information can express an independent manifestation. For example, John Cage, “4.’33, artwork in 1952, is a three-movement composition, composed for any instrument or combination of instruments. It involved a whole musical group sitting in the concert hall, but having no instruments to play or musical script because the instructor stops them for the entire duration piece of the performance. The piece of work-integrated the audience sounds instead, as feedback, thereby using feedback to generate art.

1.2.1.4 The temporality of an Artwork

The time is another type of relationship between cybernetics theories and art, by merging all the described above and implying the integral elements, resulting in “temporality” (time). Each interaction, motion, and feedback takes place in relation to temporality. Scholars of biomorphology and philosophy both claim that linking past, present, and future dissolves the diachronic appearance of categorical time and provides a unified experience of the synchronic relatedness of continuous change. Applying this to the relationship between art and its audience, the speed of response of the audience and the environment are critical factors. Thus, cybernetics art is a network of a feedback loop connected to an

interactive system, dynamic system and temporary, in which all these aspects are merged for creating the cybernetics system.

Cybernetics influenced the traditional approach to understanding the relationship between the work of art and the artist, and the artist and system, which led to the creation of art that took into consideration the relationship between the work of art and the system and the observer's interaction. Science and art are proved through cybernetics theory to combine multiple elements together as such as engineering, mechanical sculptures, biology, and even psychology demonstrated by Jasia Reichardt in her 'Cybernetic Serendipity' exhibition. So, a systematic art was created which led to new concepts in the field of art through the influence of cybernetic theories.

1.2.2 Influence of Cybernetics and Systematic

System art is affected by cybernetics art and systems theory, relating to social systems, natural systems, and social signs. It is originated from the conceptual art that is widespread during the 1960s and 1970s. System art is also associated with cybernetic art, systematic painting, systems sculptures, and systematic art, etc.

Under the feedback loop, system arts and systematic art are invented, which the world of art became related to. Due to Chilvers (2004), in early 1966 the British art critic

Lawrence Alloway created the word "Systemic art", to represent abstract art specialized by the use of simple forms as such as geometric basic forms, or repetitive images in a rhythmic systematic form. “He considered the chevron paintings of Kenneth Noland as examples of
Systemic art, and considered this as a branch of Minimal art". (Halsall (2007) (Systems aesthetics and the System as Medium)

Cybernetics offered a clear model for reconceptualizing art and education, that art education should be a behavioral system of feedback and control. For instance, creating groups of students, in which each group consisted of six students. Then they are asked to accomplish a goal. At first, they will preconception about others’ personalities, strengths, and weaknesses. But in order to achieve the goal, they will by necessity be interdependent and highly conscious of each other’s capabilities and limitations. This behavioral interaction is a kind of controlled exchange of information. This makes the observer’s communication exceed, so that it enhances human creativity, enables collaborative interaction and leads to one's better self. So, systematic cybernetics provides a wide variety of

aspects including social system, cultural system, communication system, and educational system.

The next chapter will discuss the transformation of cybernetics theories into art, including the cybernetic approach to aesthetics and its perception. In addition to the comparison and analysis of the works of both pioneer artists Nicolas Schoffer and Edward Ihnatowicz, which are used as evidence of cybernetics concepts.

Chapter 2

II. The Transformation of Cybernetics Into Art

The new scientific paradigm developed around the theories of cybernetics affected both the hard sciences and humanities. Such a shift changed epistemologies that were based on the relationship between a subject of knowledge and an object into understandings of a systemic relationship between the elements, information, function, and communication. This new concept replaced the view of nature and society as two separate entities, understanding them as inseparable. Cybernetics led to understanding nature and society as the results of information and communication. The information revolution was a decisive conceptual force that saw transformations in schools of thought from modernism into

postmodernism. Then during the 1950s, 60s, and mid- 1970s cybernetics spread all over the west and Europe and its theories were promoted. This shift did not only involve the field of science, but also the fields of art, engineering, architecture, and even computer science. This influenced literature and redefined the artworks from static objects to systemic art. Science and art combined to create new art and to open a new window for experiments and exploration. The impact of cybernetic reformulated the perception of aesthetics and directed a movement in an art practice that led to conceptual art and interactivity, such as in kinetic art. It started with the notion of conveying information in a message and expanded. The transformation of cybernetics into art was executed in several stages. The mobile sculpture called “CYSP 1”- 1956 of Nicolas Schoffer can be considered the

first cybernetic sculpture in art history. It consisted of light sensors and a microphone that grabbed variations in the fields of color and light intensity and influenced the movements of

the artwork. This experimental machine was related to the mechanic system which communicated and interacted with the public. It was

controlled by the relationship between art and the artist, and the observer with the artwork. Consequently, “art is no longer conceived as the manifestation of the autonomous and self-sufficient object, but as a cybernetic system operating in as a network of feedback loops in the cultural sphere and in society at large”. (Iuli (2013), p.236) This explains the process of feedback loop theory and its effect on cybernetic art and especially the system art of sculptures resulting in a circular process (circular causality).

Nicolas Schoffer’s first artworks were based on aesthetic perception for creating his Lumino-Kinetic art, which was developed through time and process. His new experimental discoveries transferred his work of art beyond aesthetics to divert into motion. So, the next discussions will be related to the perception of aesthetics in the cybernetics point of view. This thesis will now focus on the notion of ‘controlled information’ in cybernetic aesthetics as well as kinetic sculptures. This involves explaining the spectator’s interaction and his ability to perceive information, considering a human brain’s percentage of concentration as receiving input. This chapter will also discuss the aesthetics in kinetic art in particular of Schoffer’s artworks, and comparing it with Edward Ihnatowicz’s artworks. -

2.1 The Cybernetics Approach to Aesthetics

In an article for the publication *Leonardo,* Michael J.Apter (1969) mentioned some major factors about cybernetics and art and the use of cybernetics for the creation of art by artists. These major factors are “for example, programming computers using information theory to compose music, its main influence has been rather different”. (Apter, 1969) Although cybernetics was applied to art practice for technical purposes, as programming computers, and information theory, it was also used to create music. Its main impact on the world of art was actually its theoretical framework. The understanding of systems theory and control theory stimulated a new movement of artwork or even a new art and also influenced audience behavior, in turn. Cybernetics provided a theoretical framework for new experiments and discoveries. Furthermore, it explains the relation between the artists and their artworks, and the interaction between the observer and the art. These theories guided some artists in the creation of artwork that employed machinery. After discovering the relation between art and information theory, these artists began to develop cybernetic aesthetics. Aesthetic conception is inherently problematic because it is difficult to measure the amount of information in a particular artwork because it depends on each individual’s ability to receive it. According to a rational approach to understanding aesthetic

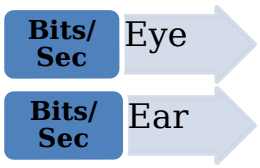
artworks, Apter believed “that this would bring an end to the era of the sophistry of cybernetic art”. (Apter, 1969)

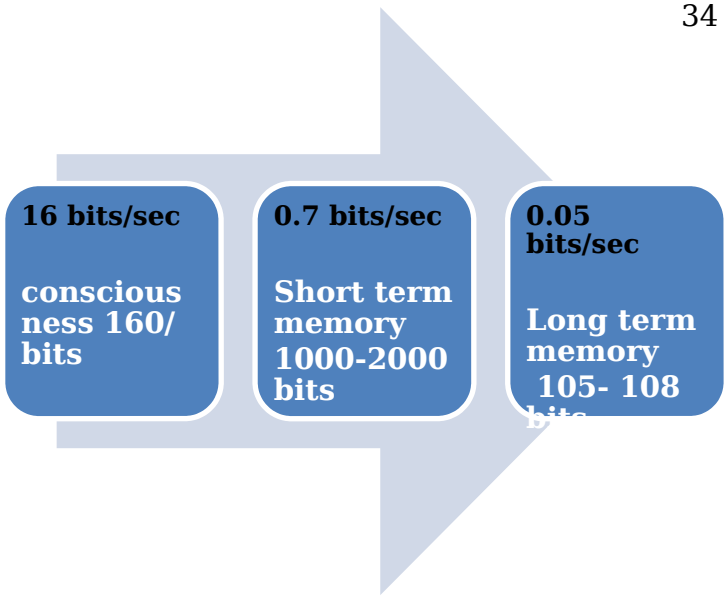
2.1.1 Flow Of Information

Information theory plays a major factor in cybernetics and cybernetic aesthetics, in which is presented generally. Although the information is difficult to measure due to its complexity, it could still be measured depending on each individual's ability of understanding. For example, the information could be detected in any of these aspects of a text or a picture, a system, a sculpture, and the environment. The estimated quantity of complexity is measured by the sum number of the primary signs. These signs could be letters, and numerals in a text, or notes for music and songs. Yet, these signs are not received easily in the same quantity or rate by each observer; there can be different behavior of interaction between each individual and the artwork. Another problem is related to each individual’s ability, reaction, and perception of the aesthetic elements found in a systemic art or cybernetic sculpture. Information theory proved to be a crucial element of digital art and cybernetic sculptures, and it is also related to other domains such as the psychology of visual perception.

According to information theory, the process of receiving information in a system is measured by the amount of information that is stored and the quantity of information flow that is spread. One unit of information is measured discretely by its quantity or/ bit, which is a decision made between two equal alternative probabilities. As a result, information flow is measured by bit/-sec. In each notion of an image or artwork, there is necessary information and unnecessary parts, such as repetition or overflow. The superfluous part is called redundancy. In both an image or system art, redundancy exists in the order, symmetry or a style of presentation, etc. Some viewers can understand the message in the artwork if they have previous experience of something similar or a related subject. Others might require more explanation or more exposure. Once the information is received to the viewer, then it depends on his knowledge of the object and the subjective capacity for catching the message. Therefore, the amount of information contained in an image or a kinetic sculpture received by the spectator is a relative quantity, which differs from one person's perception from another. Science is primarily concerned with objective knowledge, but theories have developed regarding both objective and subjective knowledge in education, psychology, and art. The following discussion will be some explanation concerning the psychology of how the brain receives and stores information.

2.1.2 Psychology and Information





The perception of psychology is observed according to the brain's way of receiving information and its understanding ways of thinking in the form of information and aesthetic perception. In order to better understand these complex models, we need to review the brain's way of obtaining and dealing with the information process. This requires explaining the following stages related to (Fig. 3), concerning (1) perceptual organs, (2) neuron network, (3) consciousness, (4) short-term memory and (5) long-term memory. The last three parts include information that is preserved, and the memory processing stage of consciousness. Whereas short-term memory provides storage of information for a limited period of time, long-term memory holds information for an unspecified longer time. Some information could be contained in short-term memory from consciousness (subliminal perception) and yet not reach the long-term memory stage.

Neutron Network

Fig.3. Diagram of the flow of information from the sense organs to the brain,(Herbert (1977), p.204)

The brain got a limited capacity for receiving information proved according to experiments. Results showed that each person is capable through the senses to accumulate between (10/*8 bits/sec) and (16 bits/sec) at a normal rate. This is the normal rate for any person before his brain gets distracted. Information could be only obtained unconsciously, in which the senses are at the rate of (16 bits/sec) as the total amount that could be achieved. A transitional phase to the neutron network (brain), where the information passes through a refining and editing process, which only necessary information remains. This results in a stage of conscious short-term memory formation related to the cybernetic concept of the feedback loop process. So, information is edited and received in the short term memory (conscious), that a person would only remember on a temporary basis.

2.1.3 Interaction of Public to Artworks

The goal behind any kind of artwork is to provide aesthetic satisfaction. (e.g.artwork as a painting, literature, a cybernetic sculpture, a kinetic art piece, a film, and dancing, etc). In general, artists produce artworks to convey their ideas. However, the cybernetics theory led to a movement that saw artists recognize that the audience is involved in direct interaction between artists and the artworks, and interactivity is a primary factor. So, audience expectation is a priority. To discuss interactivity with artworks and the concept of aesthetic perception, which is interpreted in terms of information psychology, it is important to ask if aesthetic perception should be differentiated from ordinary perception.

Both ordinary perception and aesthetic perception involve information processing. When considering the processing of information contained in an artwork, each artwork holds a unique type of information transmitted differently accordingly to each individual way of thinking. Artworks are composed in such a way as to grab the attention of the observer repeatedly and to get him/her involved to interact during the limited time of the process. So, a piece of art should attract the audience's attention, and at the same time be receivable to human aesthetics perceptive abilities. To achieve this, the amount of information processing required should be limited and measured. For instance, a temporal

artwork that contains, music, light, as kinetic art, should convey 16 bits/sec of information (least amount of time) for it to be receivable. A static work of information's speed could be measured depending on the information of a picture or cybernetic sculpture received.

Art also produces emotional responses, so it is important to consider how cybernetic aesthetics models account for emotional effects. As mentioned above, cybernetics art is based on information and rationality, and a set of transformed ideas. “ In the cybernetic sense, emotions are consciousness-awakening signals that direct attention to stimulations of importance for daily existence”. (Herbert (1977), p.204) Emotions in this sense are considered as functioning as a circuit in a series of a feedback loop, resulting in feelings that could be either positive or negative, and preserved or limited during a time or a certain situation.

This thesis will now turn to an analysis of some artworks of both artists Nicolas Schoffer and Edward Ihnatowicz, and their approaches to these ideas. Kinetic art is considered an important factor in the realm of system art, which is shown by Nicolas Schoffer's first kinetic art devices, Lumino. Later it transferred from aesthetic design art to dynamic system art. While the Artwork of Edward Ihnatowicz, SAM was the first mobile sculpture constructed by the electronics and control system. Ihnatowicz was a pioneer in establishing robotic sculptors, in

which his artwork “The Senster” is known to be the first built-in computer and controlled robotic sculpture. Through Ihnatowicz's artwork progressing process, he managed to develop his skills and evolve it into a computer digital controlled system.

2.2 The Kinetic and Cybernetic Aesthetics

2.2.1 Brief History of Kinetic Art

In 1968, Frank Popper, a historian of art and technology, in his book “Origins and development of Kinetic Art”, described kinetic art as a model recognized for its dynamic characteristics. Kinetic art flourished with the development of technology and science. Kinetic art is divided into two types: one is connected to motion and the other is static as a form but creates an optical illusion of movement. Before the 20th century, kinetic art primarily concerned aesthetic designs and dynamic style. After the 20th century, the development of industrial materials led this movement toward employing modern technological design materials to produce artworks that involved entertainment and interaction to attract the public. The entertainment-oriented kinetic design entered the realm of art, which invented a new style of art that focused on the use of energy. This development was called kinetic art.

The Bauhaus, a German art school (1910-1933), taught both fine arts and design and contributed to kinetic art and its scientific basis

through education. Kinetic art began to get promoted and grabbed the focus of research and the direction of design, laying the foundations for future design education to include kinetic art. Through time, the source of energy developed from machinery to involve electronic and digital technology. Besides the power source element, it also integrated the theoretical developments. Research has proven that in a society where technology is gradually progressing, the concepts of kinetic art evolve accordingly, slowly creating a fusion between kinetic art and technology. Recent studies have concentrated on the factor of time and on the development of kinetic art in each phase.

Popper discussed the artwork of Nicolas Schoffer mainly in his book, emphasizing the opportunities allowed by technology and artistic practices. He realized that most kinetic art devices included the feature of virtual art that is based on lighting, and became a part of the movement named “Lumino-Kinetic art”.(Fig.4) Frank Popper views the evolution of this type of art as evidence of aesthetic practices linked to technological advancement and the beginning phase of high-technology art.

Fig.4: Schoffer, N. (1970). Lumino-Kinetic art [photograph]. Retrieved from https://images.app.goo.gl/w4UofPdNEAdga28FA

2.2.2 Kinetic art and Aesthetics

Aesthetics represents a major element of art and in the design of sculptures, such as kinetic art, and especially in the ‘domestication’ of movement. Kinetic art was developed out of the fundamental movements that attempted it during the 60s. Also, in the 60s, Bruno Munari and Enzo Mari, both designers that created an experimental workshop based on the Bauhaus model, incorporated an aesthetic focus when designing household items, but they were not associated with the domestic movement. Later came Brion Gysin, a painter, writer, sound poet, and Ian Sommerville, an electronics technician, and computer programmer. The latter programmed a random-sequence generator that Brion Gysin used in his cut-up technique. They tried to progress, by displaying their “Dream Machine” in galleries without submitting it to the domestic and daily life movement. So, their work of art is considered a piece of art and not as

pure design, because during the 60s aesthetics was an important factor and used as a cause to produce art. They depended on the design for publishing their work for domestic daily uses. The development of kinetic art after the 20th led the movement to become dynamic system art based on energy and technology. This evolution in kinetic art which related it to cybernetic art.

Nicolas Schoffer was one of the pioneers who began the kinetic art movement and contributed to designs for the domestic context, choosing functionality and aesthetics. He was the first to invent kinetic devices used for homes and everyday life purposes. He integrated the form of objects and with a focus on aesthetics. Kinetic artists used sensory devices, aesthetic perception, and self-adaptation and information in their artworks. Accordingly, sensory experiences were the base of these artworks, which stimulated the reaction of the spectator. The work *Lumino,* aesthetic objects used in homes, stimulates two senses, the optical and the audio. These devices contain movable parts such as mirrors, lenses, and reflective elements creating anamorphosis, distorting realities. The anamorphosis functions by manipulating the optical eye. It deforms the shapes in both the visual system and the perception of movement. An object's physical form would look blurry and vary depending on the angle the observer is viewing it from. This forces the observer to explore the object through his/her vision and react to the

transparency effect of the object, which seemed to disappear. “According to Nicolas Schoffer, it allows a desideration of the market because the product modifies itself in endless variation”. (Rovescalli (2014), p.46). This adds variable movement and aesthetic perception to the object.

2.2.2.1 Nicolas Schoffer kinetic Art

Nicolas Schoffer was born on September 6, 1912, a Hungarian-French artist, who stayed in Paris from 1936 till his death. He is best known for his sculptures that consisted of mechanical movement, sensors, light, and sound systems. He was initially interested in painting, then diverted into Kinetic art, cybernetics, architecture, urbanism, film, TV, and music. Usually, his artworks are distinguished by their dynamism. Dynamism was founded initially by the Cubo-Futurists movement; which was developed by the Constructivist artists, such as Antoine Pevsner (Russian-born sculptor), Laszlo Moholy-Nagy, (Hungarian-painter, photographer and a professor at Bauhaus) and Ludwig Hirschfeld-Mack (German/Australian artist). These artists were concerned with evolving sculpture from the three-dimensional sculptural form into the fourth dimension, relating to time and motion. In 1948, Schoffer exhibited his exploratory artworks and developed spatial-dynamic artworks. In 1957,

he explored the Lumino dynamics by integrating light, sensor devices, music, and film, which evolved by adding the time element.

Schoffer has influenced cybernetic theories and in particular the feedback loop system, which was adopted from Norbert Weiner's ideas. Schoffer states: "A world without information is a world without stimulations". (Rovescalli (2014), P.48) In his later years, Schoffer discovered circular causality or the feedback loop, and complex art, dynamic, and interactive systemic art emerged. In his book Le Nouvel Esprit Artistique (1970), Nicolas Schoffer declares that "artists should renew their techniques, by appropriating electricity, electronics, and computer science, tools to create art". (Rovescalli (2014), p.19) His purpose was not only to create a new art movement but also to discover ways of communicating and interacting between the artworks and the audience. Schoffer stated that cybernetics added to art a solution that prevented the repetitive and redundancy of the artworks.

In 1968, an exhibition of cybernetics art took place in London, called "Cybernetic Serendipity". At this event, Schoffer's dynamic sculpture CYSP1(1956) was presented. It is considered to be the first artwork to be defined as a cybernetic sculpture. This artwork was created on feedback loop theory, or cybernetics principles and consisted of motor,

microphones and photo-electric cells. So, CYSP1 caused a deep impact on the sculpture movement.

In the late 1950s, Nicolas Schoffer had used cybernetic to apply the theory from the field of science to sculptures, like his peers, John Cage, and Iannis Xenakis. Artists of the 1960s, such as Hans Haacke, Robert Morris, Sonia Sheridan, and Stephen Willats followed their path and surpassed aesthetics to accept new information and systems that consisted of the organism rather than mechanism, dynamic processes of interaction. Thus, art was transformed completely from the focus on aesthetics in the mid 20th century to systems of control theory, cybernetics, and artificial intelligence, etc. Schoffer was among the first to experiment and implement the theory of control devices in his sculptures. The artwork, CYSP 1, is considered "one of Schoffer's linear, aluminum-frame sculptures with rotating blades". (Burnham (1975), p.343).

Nicolas Schoffer claimed that cybernetics concepts directed the field of art towards a new form of art, which renewed understandings of space, time, and light. These features are related to "Dynamism", which are applied to the artworks he created, Spatiodynamisme,

Chronodynamisme, and Luminodynamisme. Schoffer explored the concept of “space” in his work, Spatiodynamisme (Fig.5). In Chronodynamisme, he showed the element of time and experimented with influences caused by the audience’s consciousness applied to audio-visual arts. In his research on Luminodynamisme, he was concerned with light and the aesthetic visual perception of the spectator. Light benefits the mind and stimulates the emotions. Schoffer connected it to the reference of “circular causality”, society and culture. “The personality of individuals is influenced by the socio-cultural environment, at the same time, reflects the personality of the people who live in it”. (Rovescalli (2014), p.22) According to Schoffer, cybernetic systems like his artwork Lumino were supposed to communicate with the observer’s psyche and between his environments. He emphasized the importance of domestic space and its effects on human life through cybernetic concepts.

Fig.5: Schoffer N. (1958), Spatiodynamisme, [Film Director Tino Brass- Screenshots]. Retrieved from https://images.app.goo.gl/PVjie8fbxJ1BHPhQ8

2.2.2.2 Nicolas Schoffer artwork, CYSP1

CYSP 1 (Fig.6) (cybernetic-spatiodynamic construction), is a mobile sculpture constructed of four motor-powered sets of wheels, which have a variety of colors between light and dark. Schoffer had envisioned his sculptures being spread through the streets with a built-in radar system. He aimed at experimenting and exploring pure energies in which his artwork was used to materialize it. The mechanical device was placed inside it so as to be invisible. During the performance, the visual effect would be experienced as pictorial animation. In this artwork, the visual pattern and its changes are essential, along with its unsystematic duration of time. This results in a rhythmic irregular pattern that would be non-redundant and exciting for the spectator. The rhythmic movement plays an important role in this piece of work, in which the viewer forgets the vibrant colors and the exterior forms to envision himself diverting into another horizon. Therefore the intention of this artwork according to Schoffer is not to permit the viewer to remain passive and focusing only on the aesthetic elements; rather than to evoke his mind and psyche abilities to merge beyond limitation into abstraction.

Fig.6: Schoffer N. (1956) CYSP 1 [steel and aluminum, motorized, 70 7/8 x 63 in, from Habasque]. Retrieved from https://images.app.goo.gl/iVpVzk7rZ5aJaJMv5

2.3 The Development Artworks of Edward Ihnatowicz

Electronic media became more prompted in contemporary art in the mid and late 1960s, such as in interactive installation art. Robotic art was founded in the United States at the beginning of the 1960s. One of the advantages of robots is increasing productivity. Industrial robots are programmed to perform a specific task or set of tasks, which performance is involved in a repetitive manner. Artists adopted robots for further researches to improve their efficiency. This resulted in inventing robots that are innovative consisted of computer-controlled electromechanical appliances. Three main artworks were the reason for the creation of robotic art that outlined the history of robotic art, which led it to different

directions and development. Each artist explored robotic art in his own way and developed his own strategies, and interrelated it to “other media, systems, contexts, and life forms”. (Kac (1997), p.60) These pioneer artists are, Nam June Paik (Korean/American artist) and Shuya Abe's (Japanese artist) artwork Robot K-456 (1964), Tom Shannon's (American artist) artwork Squat (1966), and Edward Ihnatowicz's The Senster (1969-1970). Their artworks affected robotic art towards new directions and opened new privileges in interactive and behavioral artistic elements. Edward Ihnatowicz was among these artists and the first to built computer-controlled robotic sculpture the senster. He was a pioneer in establishing robotic sculptures and raising interactivity, which consisted of instant behavioral autonomy interaction in robotic art. This gave the robot a new identity and ability to respond to humans’ motion and change and react to different situations by itself. He was born in Poland (1926-1988). Then he moved to Britain in 1943 and went to the Ruskin School of Art in Oxford from 1945 to 1949, where he took sculpture courses and at the same time he studied film-making and photography. After he emigrated to England and isolated himself, he created “The Senster”, a biomorphic computer-controlled robotic creature and exhibited at Evoluon. Whereas the permanent showplace of the manufacturing firm Philips, in Eindhoven, Holland, from 1970 to 1974 till it was dismantled. Therefore, these artworks obtain specific meaning when reviewed today since they distinguished a new aesthetic conception that laid the

foundations for robotic art. These three different types of robots are directly related to conceptually and are hybridized in some of their artworks.

During the 1950s, noncommercial robots were developed generally for entertainment and scientific purposes until the 1960s. Whereas, the developments in Kinetic art that began decades before robotic art led to free sculpture from a static form and reintroduce machines in the field of art. This shift that influenced robotic art and directed it into new directions and prompted the interactivity and behavior aspects. This is illustrated in Ihnatowicz 's artworks, which are based on cybernetic interactivity art and voice. This combination of organic and electronic, which form cybernetic art. Through his expertise in mechanics and electronics, enabled him to develop his knowledge and skills by demolishing and stripping off parts of cars. This taught him a lot about generators and their motion. For example, he used hydraulic brakes and disassembled its parts to recreate them. His very first work was “hydraulic pistons”, constructed with some servo valves. At first, he did not realize their actual function, and through researching their use, he discovered that the center of his work was connected to control systems.

2.3.1 Artwork SAM

Ihnatowicz 's artwork “SAM” was a mobile sculpture constructed by electronics and control systems. This interesting interactive sound sculpture was noticed as his “first genuine piece of sculpture”. (Zivanovic (2005), p.103) It has a form of a flower based on sensors that made it sensitive and responsive to its surroundings and was able to move directly towards sounds. This feature the voice, which differentiated Ihnatowicz 's artwork from his peers. For example, Shannon’s “Squat” is a cybernetic system art based on interactivity and stimulated by the touch. Through the aspect of touching interactivity was created, which enabled the viewer to switch it automatically by turning on its sensors and motors. The artwork SAM was exhibited at the “Cybernetic Serendipity” exhibition in London, 1968. It is composed of a long spine-like assembly of aluminum castings. On top of it, a “flower like-glass sound reflector with an array of four small microphones mounted immediately in front of it”. (Fig.7) (Zivanovic (2005), p.103) The spine contained little pieces of a vertebra, in which each one was set in opposition to the other, one that has a horizontal plane for twisting it and another for steering it up and down. Each piston had a small scale for motion connected all together. Consequently, the column was able to articulate, twist, and move on both sides. The microphones were organized in two pairs, and each one was directed either horizontally or vertically with a circuit that was used for measuring the signals of the sounds. The aim of this circuit was to control the hydraulic servo valves so the head would be able to turn in all

directions to face the sound it was receiving. SAM was sensitive to noise, so when people were interacting they would attempt to catch its sensor, then prompt a movement in response.

Fig.7: Ihnatovitz E. (1968) SAM [Sound Activated Mobile, a spine-like column of aluminum castings, kinetic sculpture]. Retrieved from https://images.app.goo.gl/bVgmDYxKtkDZnLiYA

After the SAM project, Ihnatowicz returned to his studies and experiments on the subject of control systems engineering, where he found his passion for computers. He also explored the processes involved in the movement of the elbow. The motion was captured on his analog computer programs. This led him to discover the stimulation motion developed by people that were using digital circuits of series and control. Then he taught himself digital computer programming in order to produce his own digital converters with a high level of performance, to create his unique artwork the Senster.

2.3.2 Artwork The Senster

Ihnatowicz's work the senster is a robotic sculpture based on cybernetic interactivity, which sounds or voices aspects that stimulate it to permit participation with the audience. This feature is crucial for creating interaction behavior in his work. On the other hand, Nicolas Schoffer's kinetic art is based on the optical aspect that stimulated the visual senses through lights and dynamism. For example, Schoffer's work, CYSP 1, evoked the spectator's mind and psyche to create the interaction, which led to communication interaction with the audience. —The senster is also based on an articulation of a lobster's claw. It was considered to be the world's first computer-controlled robotic systemic sculpture, which took

Ihnatowicz many years to complete. It responded to motion and sound within one second or two. The senster was sensitive to loud voices, it would directly shy away protecting itself in case the voices were disturbing. It was exhibited in 1970. His contacts enabled him to build a large network of relationships with people in the Department of Mechanical Engineering of University College London, where he got his information and support. After the Senster was transported to Eindhoven in June 1970, then it was rebuilt in Evoluon where he showed it. While programming the Senster and examining the interaction between it and the observers, Ihnatowicz realized that the size of the sculpture was not as important as the behavior of the sculpture that generated such an intense response from the spectators. The reactions of the audience were chaotic and some were scared to approach it. The scale of the Senster was huge: 15 feet (5m) long and 8 feet (2.4m) tall and it was “described as a dinosaur”. (Zivanovic (2005), p.105) (Fig.8) It was created from welded steel tubes. It had six joints along the neck and hydraulic actuators welded on the head. The sculpture’s structure was similar to SAM, in that the microphones were located in the same place but the sound system was placed outside, replaced with software. “It soon became obvious that it was that behavior and not anything in its appearance which was responsible for the impact which the Senster undoubtedly had on the audience”. (Zivanovic (2005), p.105)

Fig. 8: Ihnatovitz E. **(**1970) The Senster [a large hydraulically actuated robot, 8 feet (2.5m) high and 15 feet (4 m) long, welded steel]. Retrieved from https://images.app.goo.gl/Rgrd2BGQR2myFB7T6

Moreover, robotic art is a problematic issue by itself. When asking one's self, what is robotic art? Robotics art deals with complicated matters, such as servo electronics and digital computer and controlled system. It also concerns the Mythological traditions of various cultures, which initiated a synthetic creature, (robotic art). For instance," the Greek story of Galatea, a statue brought to life by the goddess Aphrodite." (Kac (1997), p.60) Edward Ihnatowicz discovered after creating SAM that its form was actually found in nature, realizing that it looked like a neck bone shape. But he had never intended to imitate it and the same with Senster, which seemed like a lobster. The Lobster was constructed of simple pivot joints, and regardless of each leg's simplicity and limitation, it was able to perform most of the movements. After analyzing Edward Ihnatowicz's

works, now I am discussing the similarities and differences between his artworks and Nicolas Schoffer's artworks.

The difference between the artworks' of Nicolas Schoffer and Edward Ihnatowicz, is that Ihnatowicz used in his experimental artworks analog circuits supported by computer programming or software. The role of a hydraulic servo system and control system was the main focus in the construction of his robotic dynamic sculptures. The senster was described as an intelligent creature that reacted to motion and sound. Its potential attracted the audience at large. On the other hand, the argument is on the use of computers in art at that time. While the concern of the public was still related to "the sequence of an image and the use of static images. (e.g. using a mobile plotter to produce such images.)" (Kac (1997), p.62) So, he merged computer programming software with the behavior of artwork into real space. Schoffer, on the other hand, initially produced his kinetic devices for domestic design and for aesthetic purposes. He focused on three important factors related to space, time, and light that led to dynamism. His interest, however, was based on human domestic space and the influence of the source of light on the psychology of the individual, thinking about the reactions of the audience towards his artworks. His main focus was on the visual aspect, which created the virtual reality type of interaction within the space. Ihnatowicz's artwork depended more obviously on impacting the physical senses, such as sound and touch,

while with Schoffer’s artwork, the sense that was most involved in the optical dynamic system. Both used the dynamic system and experimented with the element of interactivity, between the artwork itself and its spectator. Kinetic art helped to free sculptures from the static object and reformed it and represented machines in a dynamic merged with technology and electronics. This influenced robotic art and created new works of art. Among them was the artwork of Ihnatowicz’s the senster, which relied on the theory of “artificial intelligence”; his machines were completely systemic and programmed. Whereas Schoffer’s artwork “ CYSP1, was built in an asymmetric way purposely so as to avoid repetition and redundancy. Even the timing and movement are random to add the factor of excitement for the audience. Therefore, Schoffer's work of art intention is to affect the audience through the mind by using light to stimulate their reactions and moods. Whereas, with Ihnatowicz’s Senster, the experience was very different and attracted some negative responses and reactions from the audience. Its huge scale and its behavior instigated a direct response from the spectator and its behavior respond received more importance and consideration than its aesthetic characteristics. Cybernetics theories were responsible for the innovations behind these artworks. Feedback loop and control system that formed these artwork’s interactivity and behavior.

Conclusion

The Impact of cybernetics theories in the realm of art played a crucial role both in the scientific and artistic fields and affected our society and nature. It influenced the artists and their artworks from various aspects, which led these artists to explore and experiment with new materials. To combine both science and technology with their artworks resulting in creating a new form of art. This opened a new futuristic point of view concerning art and the way of perceiving it aesthetically, intellectually, conceptually and sensually. The development of cybernetics in the realm of science led to artistic developments and explorations as well. The major developments are the three basic concepts, which are based on information theory: the notion of a message and measured amounts of information; on control theory using the feedback loop, and on automata theory applied to Alan Turing's machines and network. These are the theories that redefined art and science and led to different developments that created a connection between art and between all systems.

The relationship between cybernetics theories as information and feedback were major factors used in art and which led artists as Nicolas Schoffer to explore and experiment through his artworks Lumino devices. This kinetic art was able to influence the viewer intellectually and psychologically by its vibrant light source and optical senses. According to

Schoffer light benefits the mind and stimulates the emotions. He connected it to the reference of “circular causality”, society and culture. The personality of individuals is influenced by the socio-cultural environment, at the same time, reflects the personality of the people who live in it. This created a relationship between cybernetics concepts and art by understanding the complex human behavior and its interaction due to the artworks, which are a type of communication resulting in the “Artistic Behavior”. The purpose of artistic behavior is to stimulate the emotional and intellectual part of the human nervous system. Schoffer was able to renew the concepts of space, time, and light. He applied these features that are related to “Dynamism”, in his artworks Spatiodynamisme, Chronodynamisme, and Luminodynamisme. He claimed that cybernetic systems like his artwork Lumino were supposed to communicate with the observer’s psyche and between his environments. He emphasized the importance of domestic space and its effects on human life through cybernetic concepts. On the other hand, CYSP 1, performed some kind of visual effect reflected as pictorial animation. In this artwork, the visual pattern and its changes are essential, in which they created a rhythmic irregular pattern. This influenced the viewer’s thoughts and the visual senses to stimulate his mind, causing the observer's mind to go beyond the forms to envision himself in another dimension. Therefore, Schoffer’s intention behind his artwork is to lead the spectator to seek and

participate through evoking and stimulating his mind and psyche abilities to merge beyond limitation into abstraction.

The impact of cybernetic concepts redefined the perception of aesthetics and information theory that led to conceptual art and interactivity, such as in kinetic art and robotic art. It started with the notion of conveying information in a message and expanded to communication and controlling automation. The transformation of cybernetics into art was executed in several stages. The convergences between cybernetics and art can be classified into four steps. The first is concerned with interaction with viewers; the second involves putting visual forms into actual motion; the third relates to the concept of the feedback loop, and the fourth focuses on temporality. These elements are the foundation of each cybernetic artwork. These elements caused a shift from static art to system art, which influenced contemporary art. Where the senses are involved with the interactivity of the artwork and the participation of the spectator became essential. The interaction and behavior of the artwork became more important than the aesthetic feature as in the senster. Edward Ihnatowicz ‘s artwork the Senster was a different experience than, CYSP 1 of Schoffer because Ihnatowicz used analog circuits supported by computer programming or software in his artworks. The role of a hydraulic servo system and control system was the main focus in the construction of his robotic dynamic sculptures. The

senster was like a lobster creature that reacted to motion and sound. These aspects are caused by the spectator that the senster reacted to. Whereas with Schoffor's CYSP 1, the artwork that was in motion causing the audience to interact with the mind. So, in the senster, the machine was interacting according to the sounds and behavior of the audience and would shy away in case of high frequency. Ihnatowicz merged computer programming software with the behavior of artwork into real space. On the other hand, kinetic art helped to free sculptures from the static object and reformed it and represented machines in a dynamic merged with technology and electronics. This influenced robotic art and created new works of art. So, both artworks had the aspect of a dynamic system, but each one in its unique way. Therefore, cybernetics theories were responsible for the innovations behind these artworks. The feedback theory and control theory were the keys to creating these artworks. So, these pioneer artists, redefined and reformed the art that we know today. Still, remain unsolved questions that still need to be discovered. Like, what should be the role of art in advanced, as technology and society? Should be art composed of machines? Or are ready-made objects considered art? Is art dead or does it has a future?

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